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Title: Beta Emission & Bremsstrahlung

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Los Alamos NATIONAL LABORATORY

Beta Emission & Bremsstrahlung

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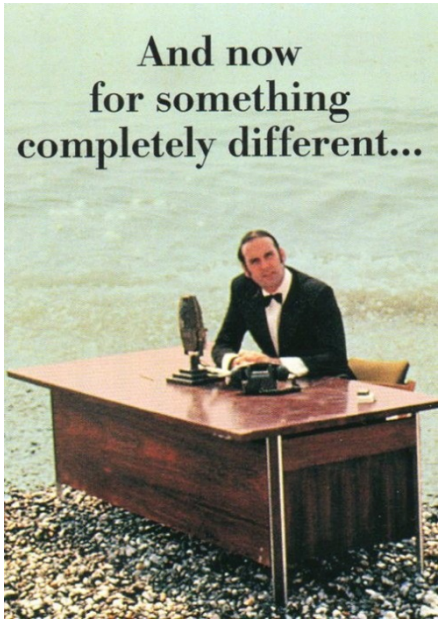
Introduction

- What is beta decay?
- What is bremsstrahlung?
- Why do we care in a gamma-ray spectroscopy class?

What is beta decay?

1. The death of a Siamese fighting fish?

2. The Rise of VHS?



3. Something completely different?

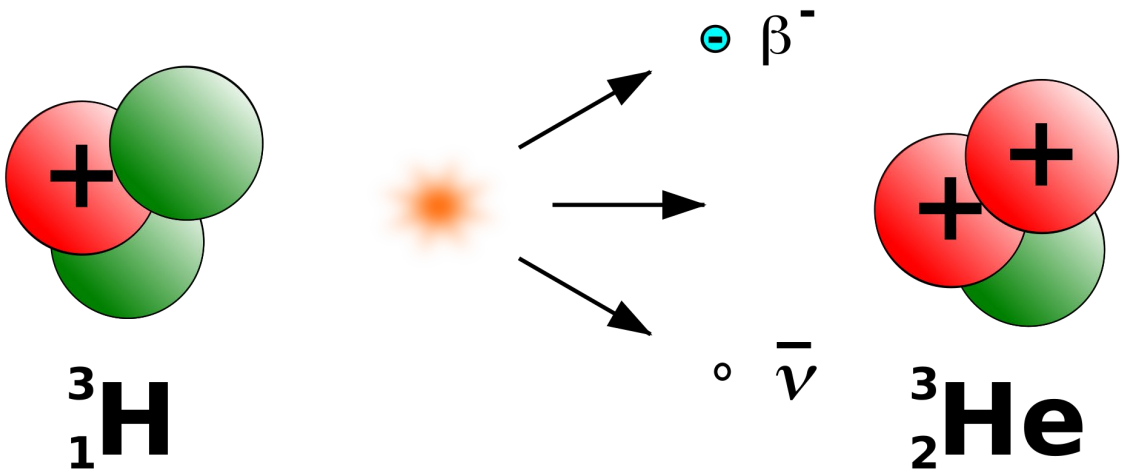
Beta Decay

- When a nucleus has too many protons or neutrons it may undergo **beta decay**
  - Too many neutrons → β^- decay
  - Too many protons → β^+ decay

- β^+ particles
  - are the same as positrons
  - quickly undergo pair annihilation

- β^- particles
  - are identical to electrons but originate in the nucleus
  - radiate a continuous range of photons as they decelerate in various media

Beta Decay example- Tritium decaying to He-3



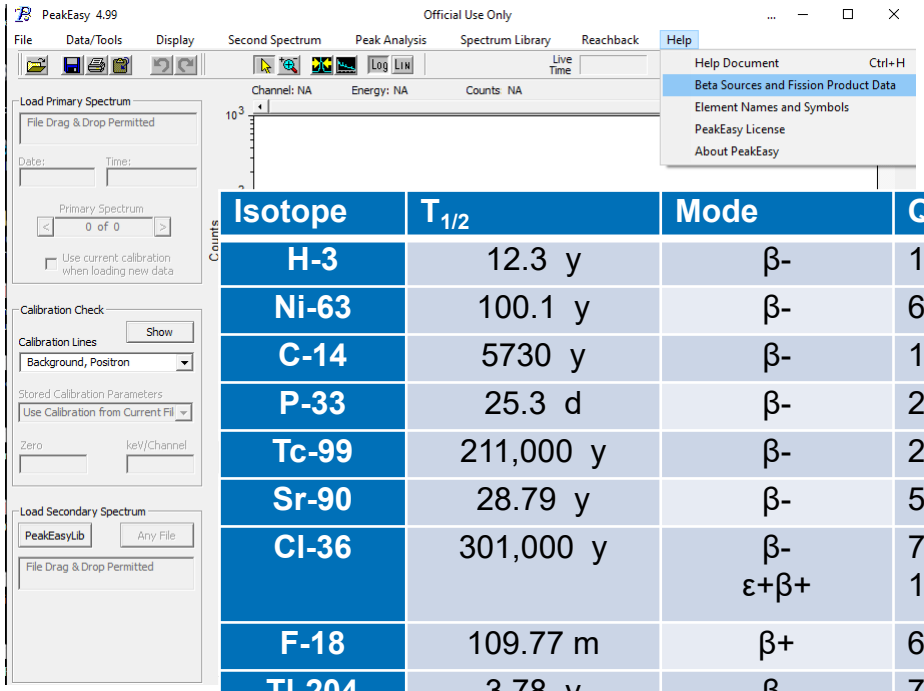
$E = mc^2$ ⇨ **Mass-Energy difference of ^{3}H and ^{3}He in MeV*:**
2809.449895 - 2809.431302 = 0.018593

This is the "endpoint energy of the emitted β particle"

* atomic masses

∘ $\bar{\nu}$ The other particle given off, an anti-neutrino. It is undetectable by typical radiation/search detectors.

“Pure” β Emitters



Isotope	$T_{1/2}$	Mode	Q-value (End Point Energy)
H-3	12.3 y	β-	18.591 keV (Branch: 100%)
Ni-63	100.1 y	β-	66.945 keV (Branch: 100%)
C-14	5730 y	β-	156.47 keV (Branch: 100%)
P-33	25.3 d	β-	248.5 keV (Branch: 100%)
Tc-99	211,000 y	β-	293.7 keV (Branch: 100%) Weak gamma
Sr-90	28.79 y	β-	546.0 keV (Branch: 100%) Contains Y-90
Cl-36	301,000 y	β- ε+β+	708.6 keV (Branch: 98.1%) 120.1 keV (Branch: 0.01%)
F-18	109.77 m	β+	633.5 keV (Branch: 96.7%)
Tl-204	3.78 y	β- ε	763.72 keV (Branch: 97.1%) 347.5 keV (Branch: 2.9%)
P-32	14.3 d	β-	1710.7 keV (Branch: 100%)
O-15	122.2 s	ε+β+	1732.0 keV (Branch: 99.9%)
C-11	20.4 m	ε+β+	1982.5 keV (Branch: 99.8%) 960.5 keV (Branch: 0.24%)
N-13	9.96 m	ε+β+	2220.4 keV (Branch: 100%)
Y-90	64.00 h	β-	2280.1 keV (Branch: 100%) Weak gammas

Question Time

- What industrial and medical isotopes are you familiar with are beta emitters?

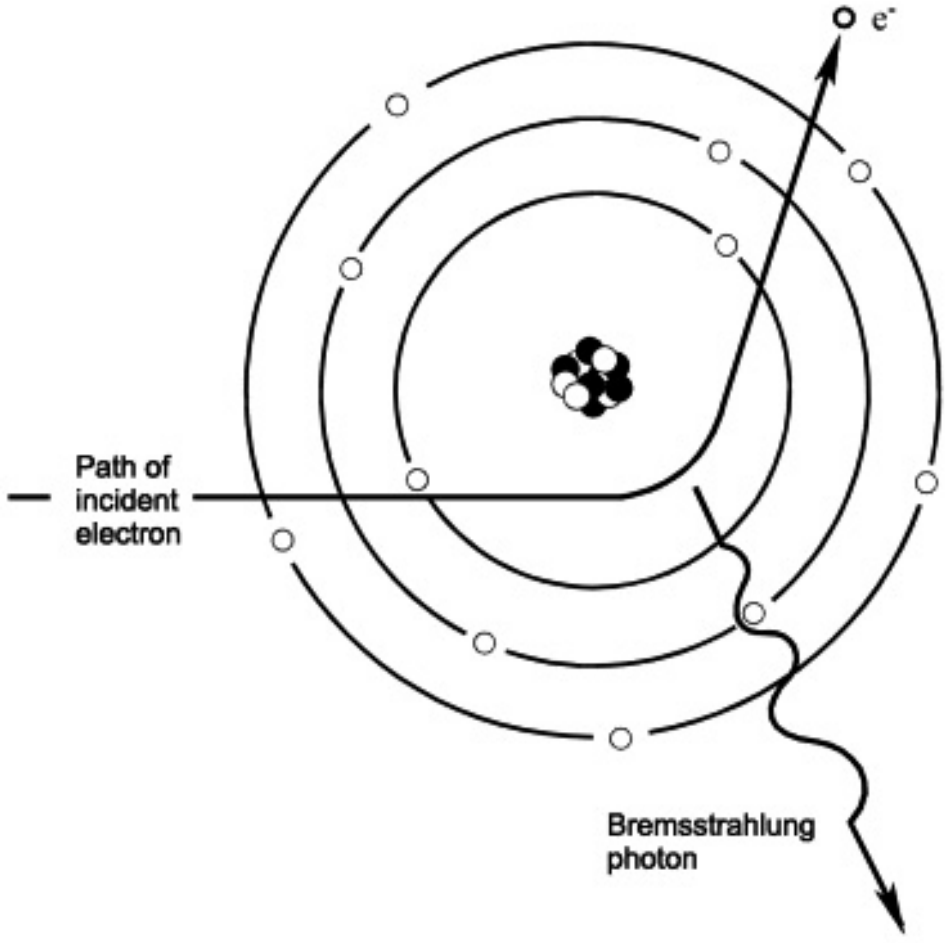
- Enter answers in chat

What is Bremsstrahlung or “Braking Radiation”?

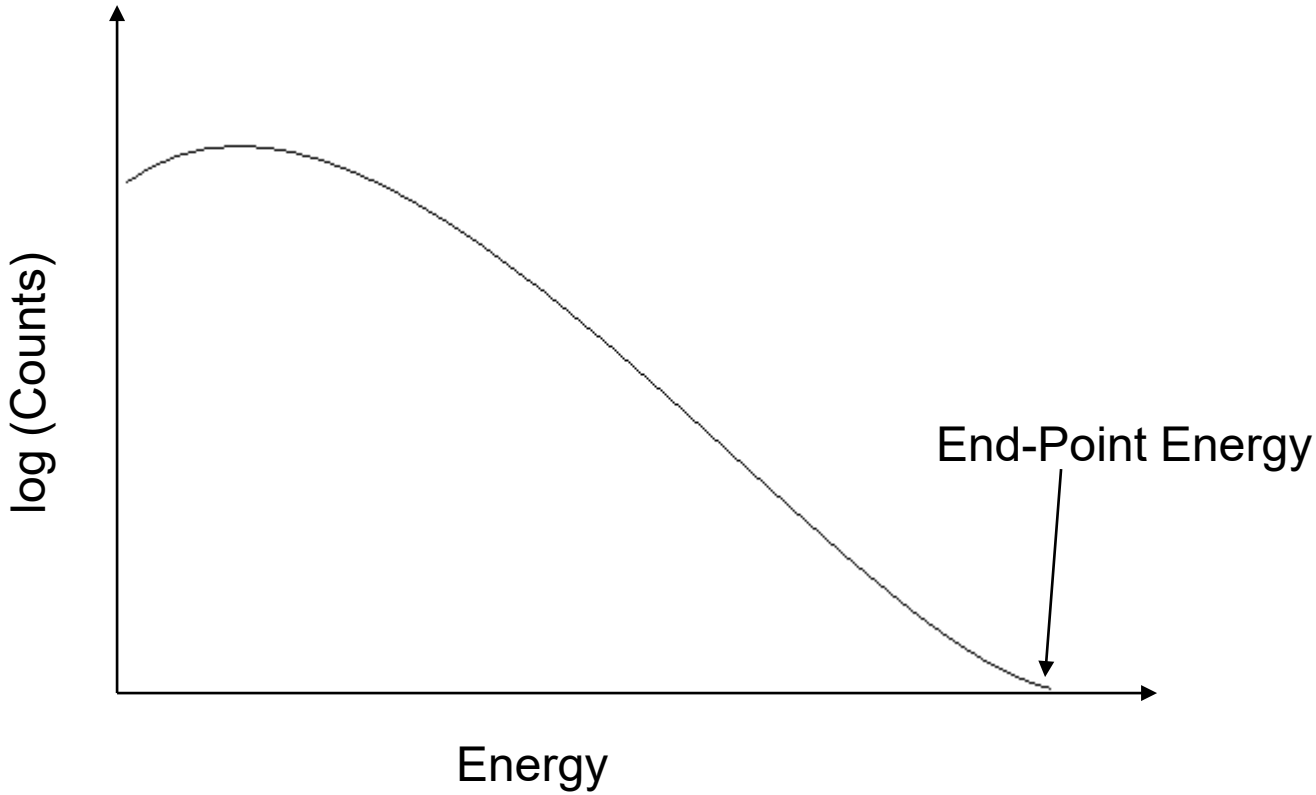
When a free charged particle enters the influence of another charged particle, it is deflected, like a comet passing the sun.

The charged particle is slowed and radiates photons.

The emitted photons are in a continuous range of energies (up until some maximum or “endpoint”).



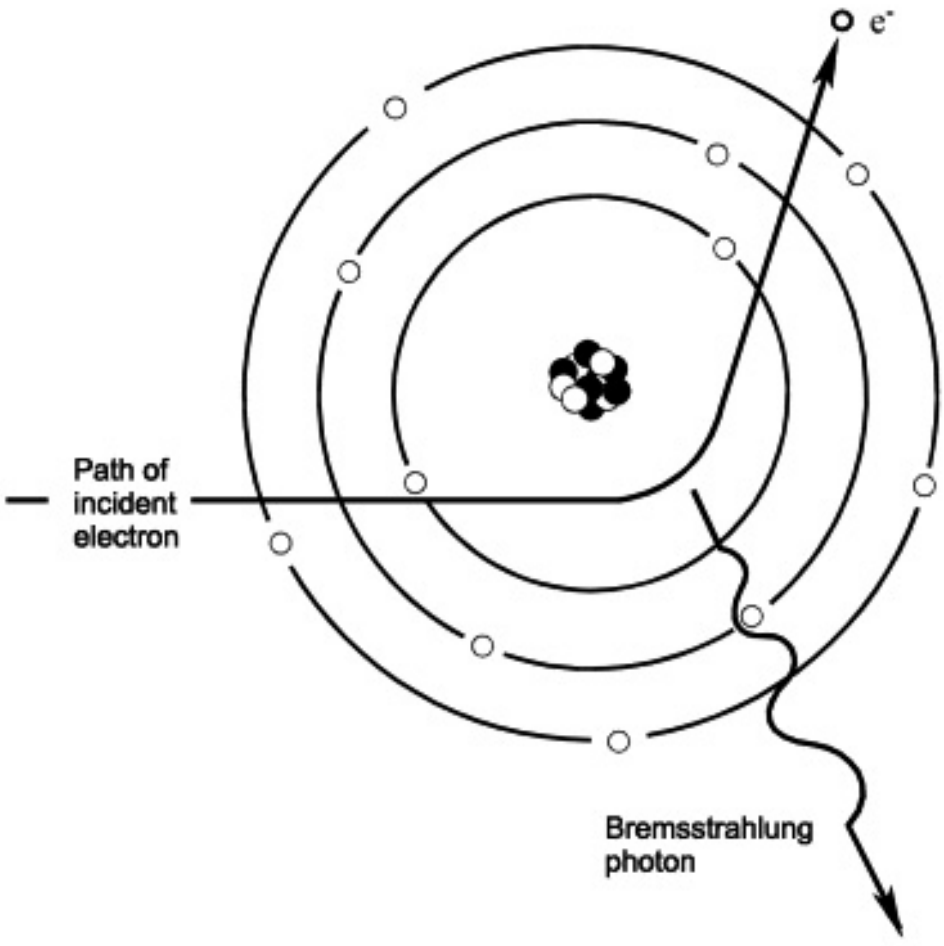
Idealized β^- Spectrum



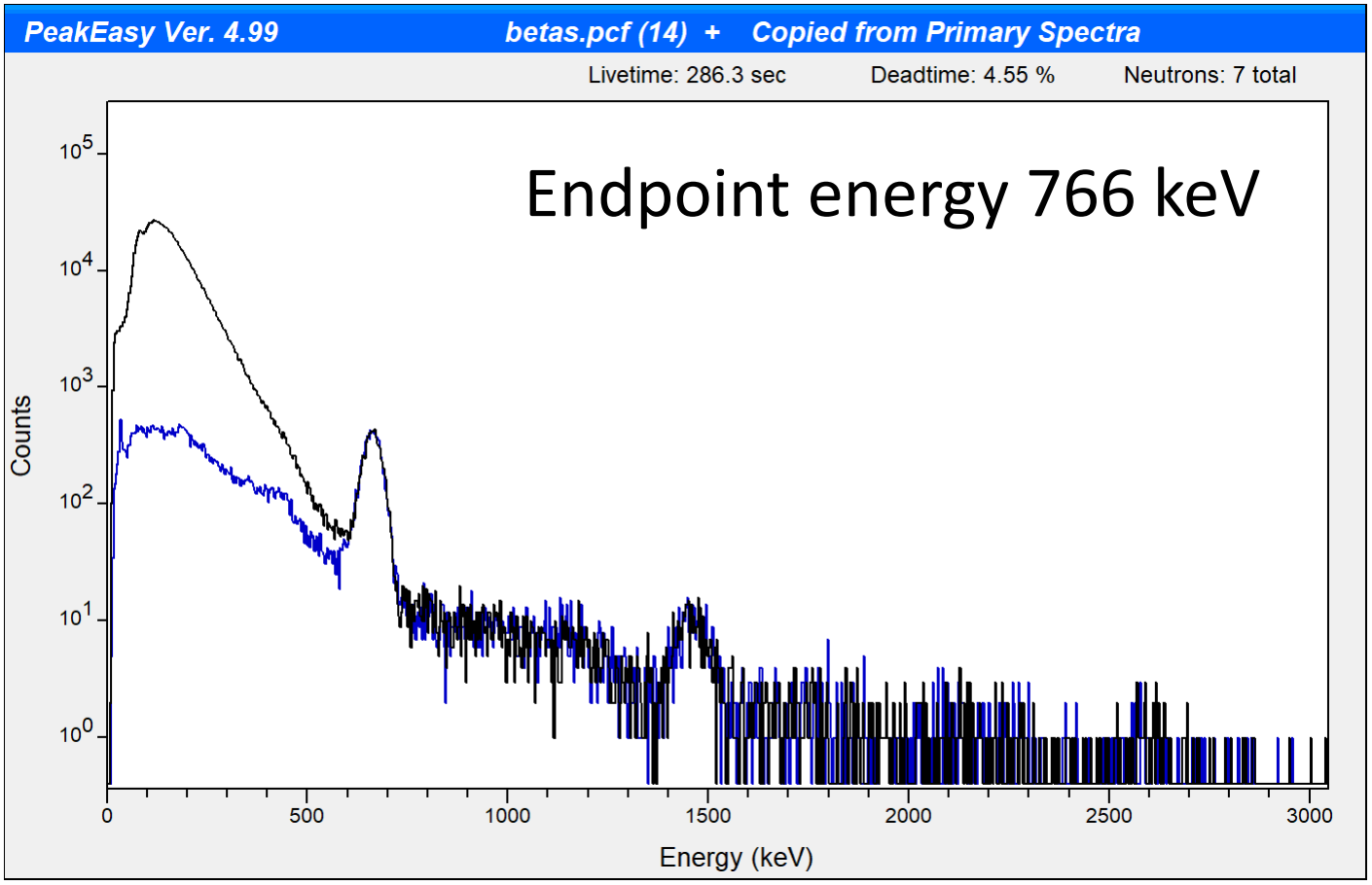
Question Time

What properties of the **charged particle** impact the bremsstrahlung?

What properties of the **material** the particle is passing through impact the bremsstrahlung?



Tl-204 Bremsstrahlung (Identifinder w Cs-137 seed)



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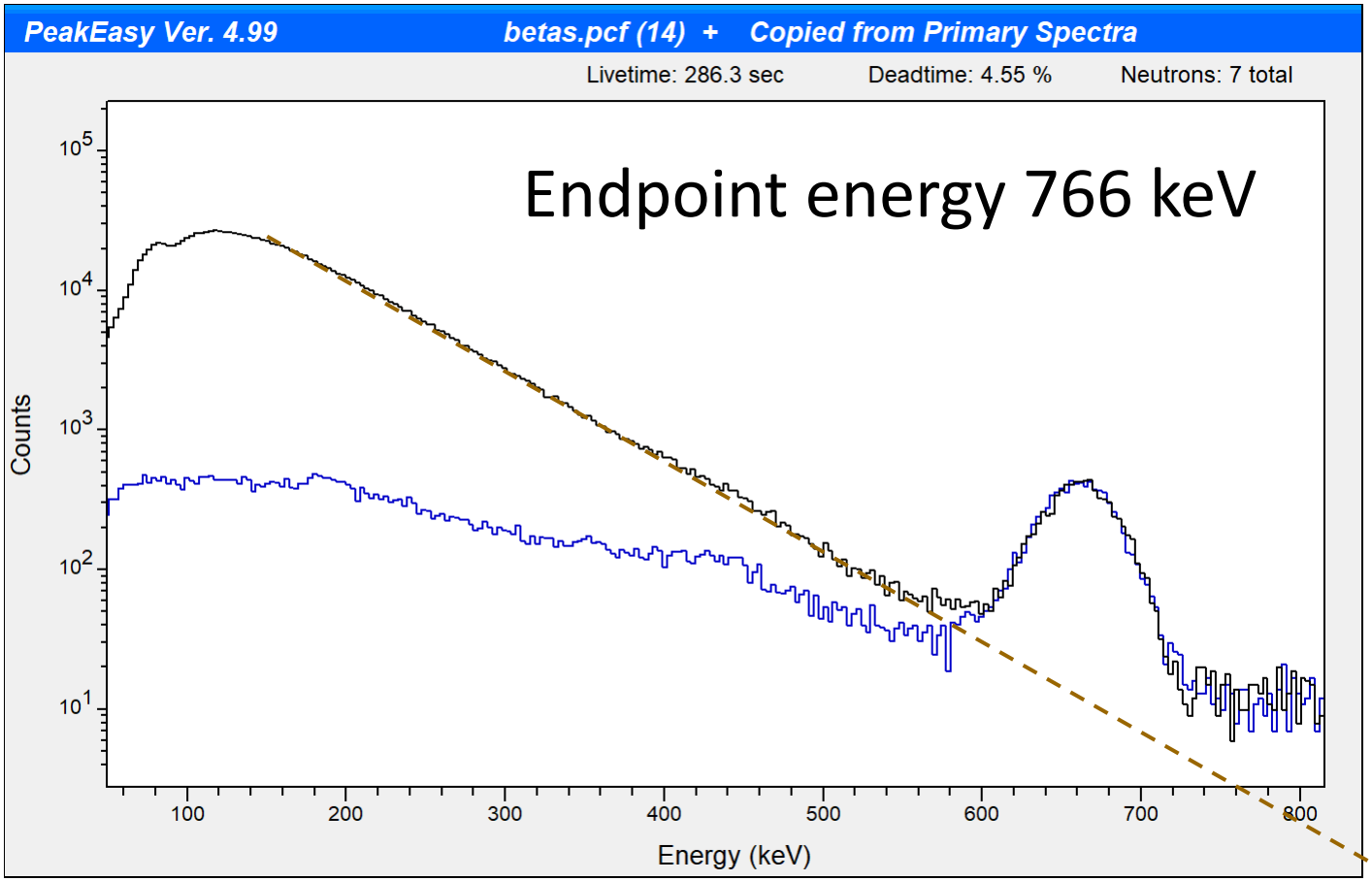
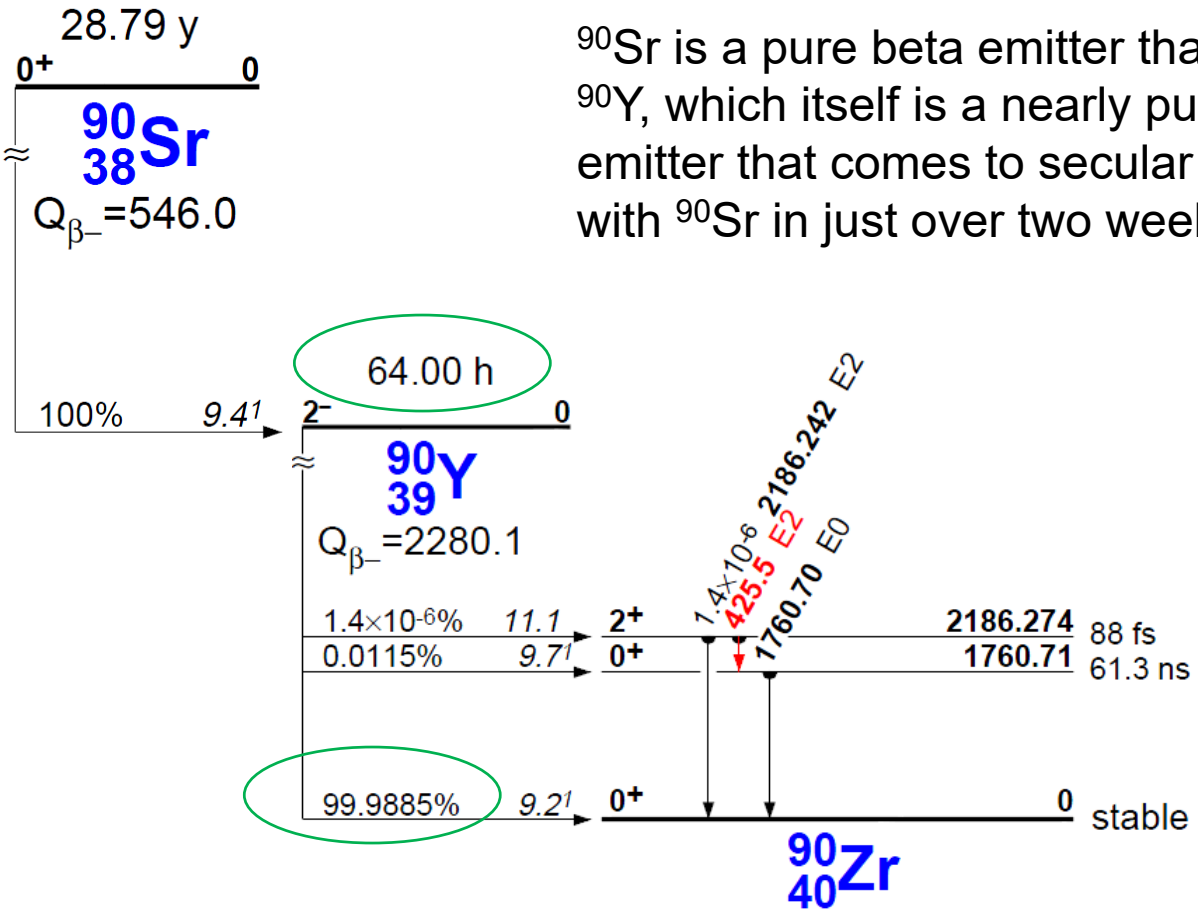
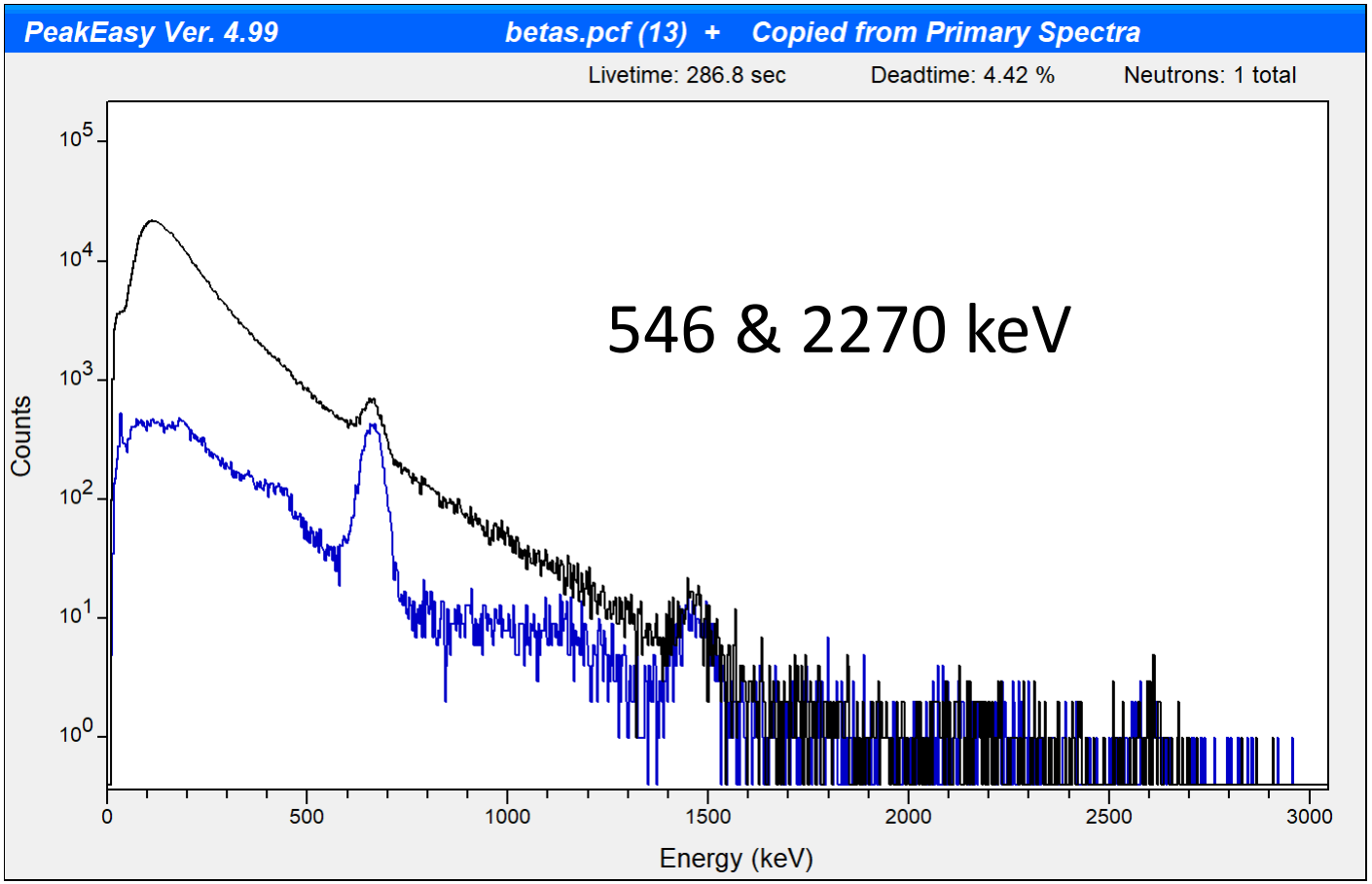


^{90}Sr / ^{90}Y Level Scheme

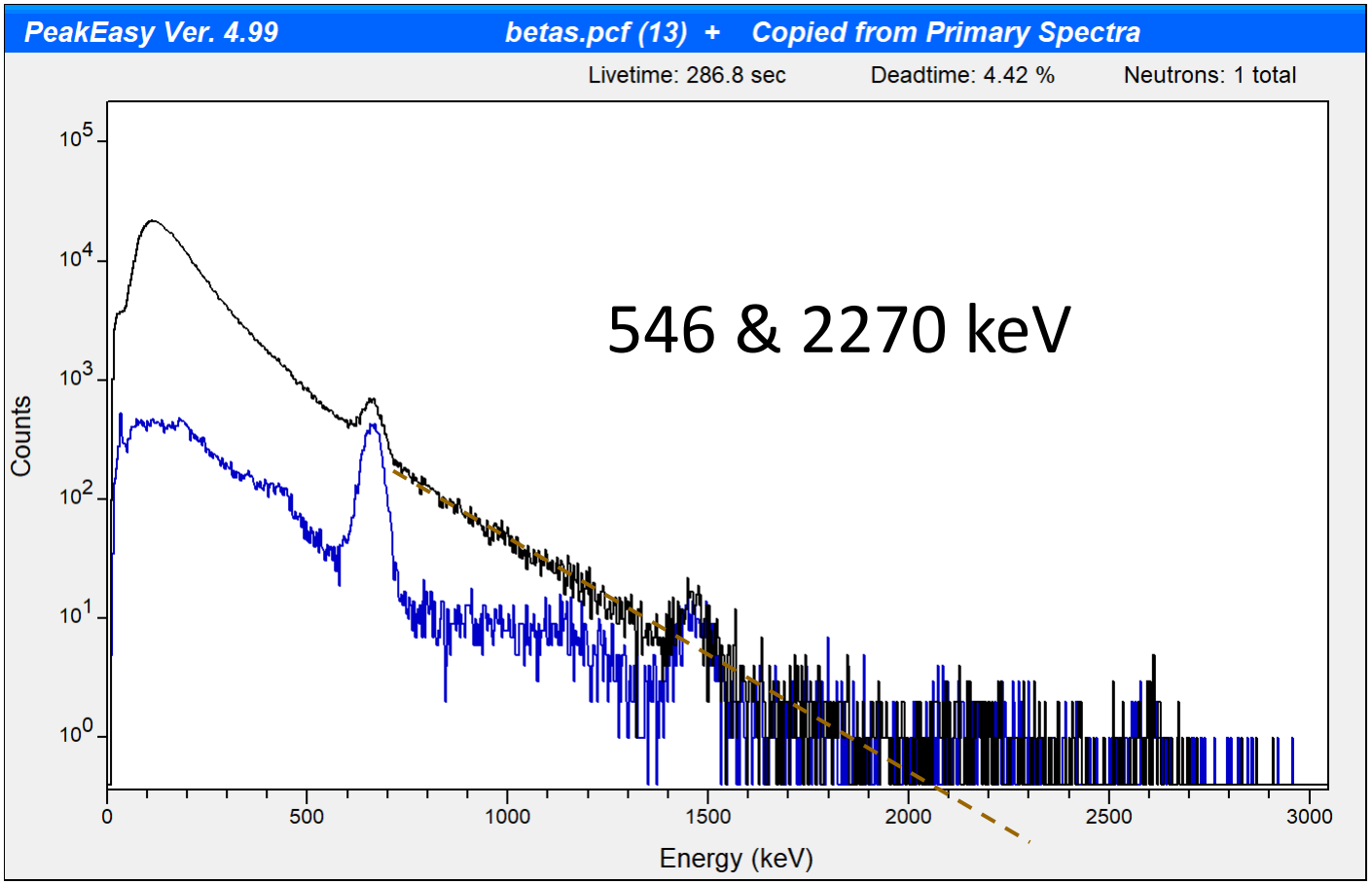


^{90}Sr is a pure beta emitter that decays to ^{90}Y, which itself is a nearly pure beta emitter that comes to secular equilibrium with ^{90}Sr in just over two weeks.

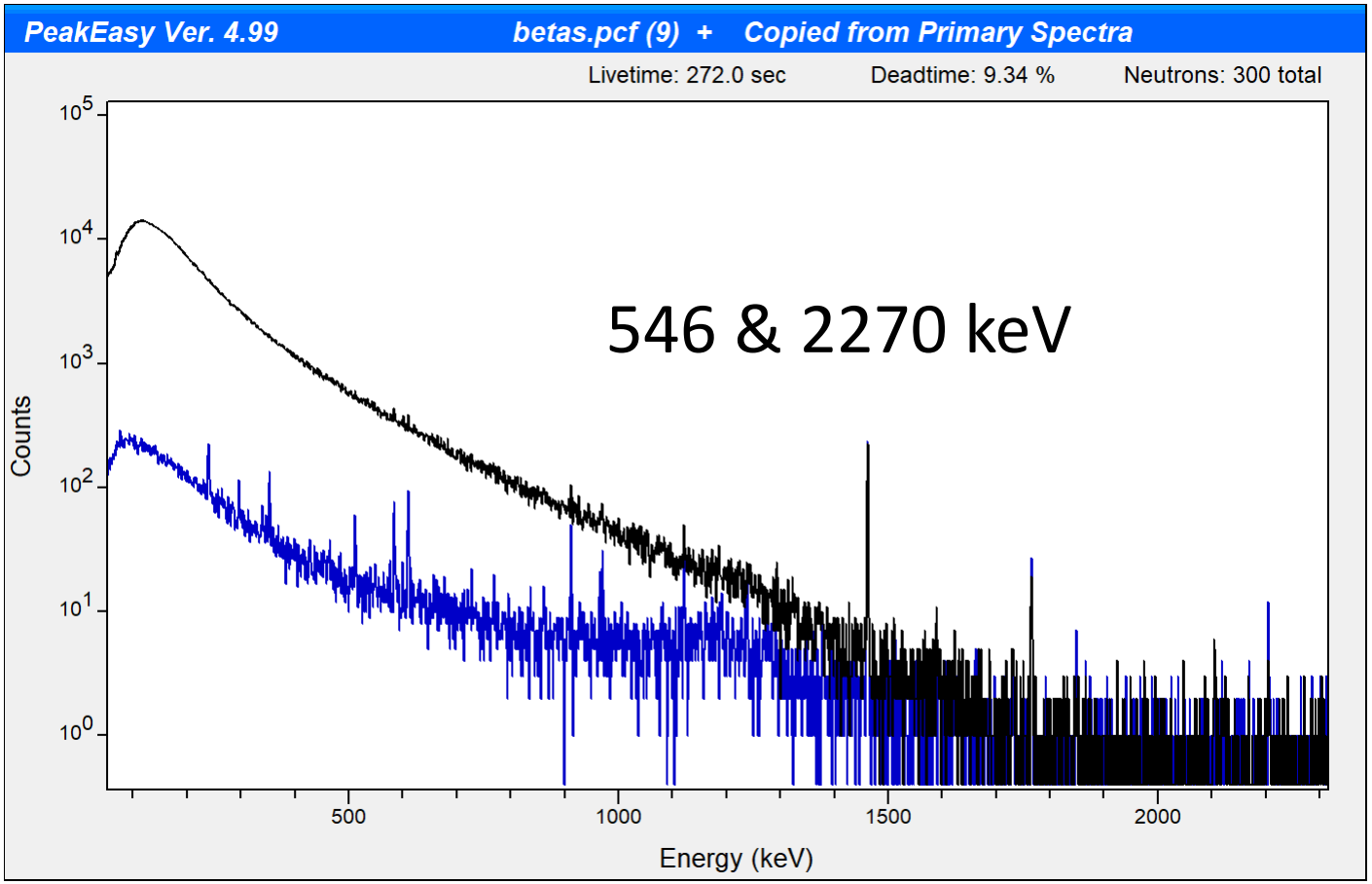
Bremsstrahlung Sr/Y-90 (Identifinder w Cs-137 seed)



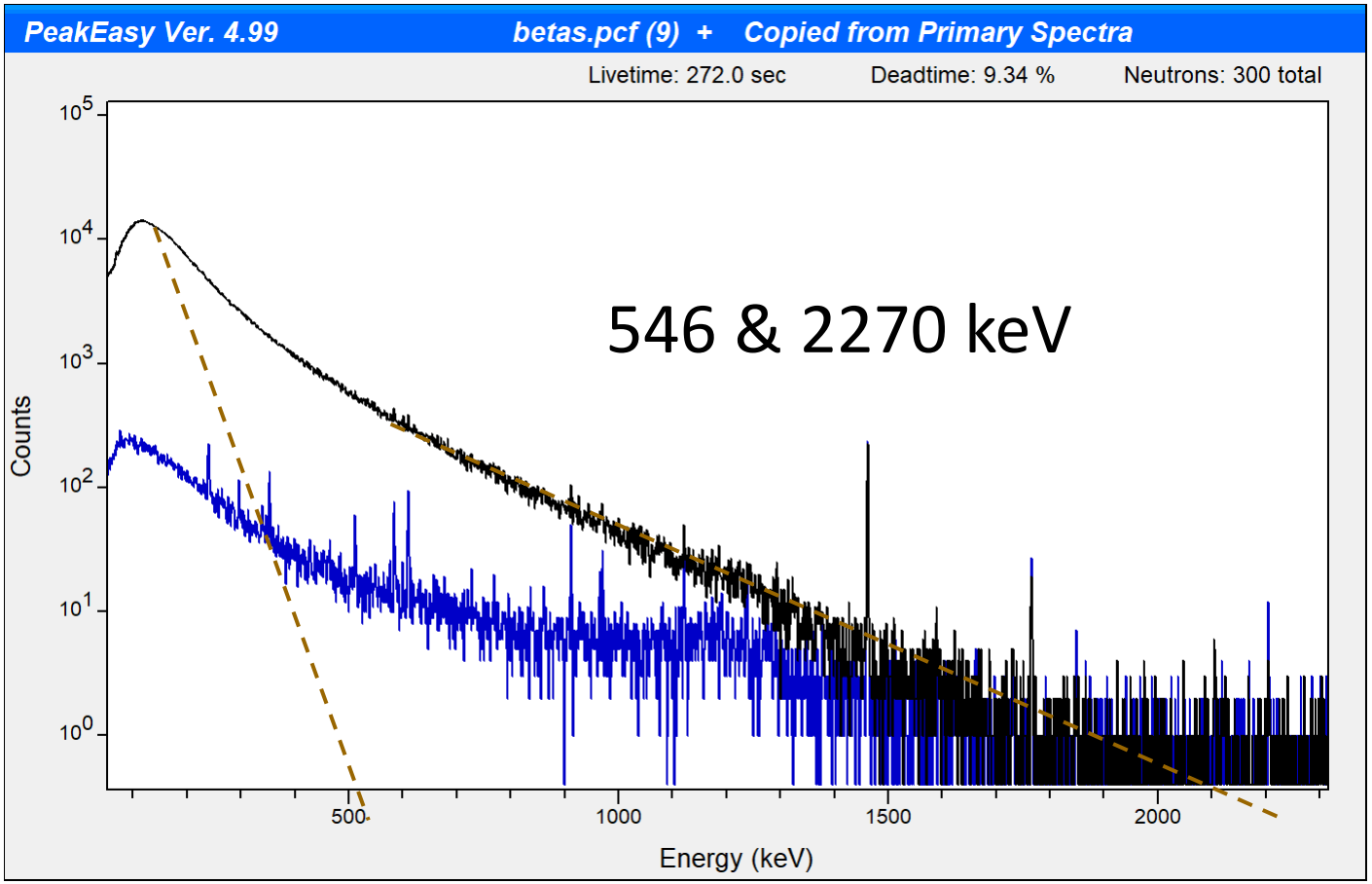
Bremsstrahlung Sr/Y-90 (Identifinder w Cs-137 seed)



Bremsstrahlung Sr/Y-90 (Detective X)



Bremsstrahlung Sr/Y-90 (Detective X)



Question Time

- What is sometimes the most definitive answer you can give about a spectrum containing a beta emitter?

- A) High confidence isotope ID with activity estimate from end point energy
- B) beta emitter present
- C) nothing, need longer count time

Summary

- Bremsstrahlung is continuous radiation produced by beta particles decelerating in matter
- Different beta emitters have different endpoint energies
- High-energy betas interacting with high-Z materials will more likely produce bremsstrahlung
- Depending on the data, sometimes all you can say is that a beta emitter is present